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EFFECT OF POWER ON THE STICK-FIXED NEUTRAL POINTS

OF SEVERAL SINGLE-ENGINE MONOPLANES AS

DETERMINED IN FLIGHT

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EFFECT OF POWER ON THE STICK-FIXED NEUTRAL POINTS OF SEVERAL SINGLE-ENGINE MONOPLANES AS DETERMINED IN FLIGHT

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SUMMARY

The effect of power on the variation of stick-fixed neutral point with lift coefficient is presented for several single-engine monoplanes. The tests were made with power off and with rated, climbing, or wave-off power and with flaps neutral and deflected. The results show that with power off and flaps neutral or deflected the neutral point remained fixed or shifted rearward with increasing lift coefficient. With power on, the neutral point usually shifted forward of the power-off location. With flaps neutral and for lift coefficients up to 1.2, the maximum forward shift of the neutral point, with respect to the power-off location at low lift coefficients, was 4 to 5 percent of the mean aerodynamic chord (M.A.C.) in most cases and 8 percent in one case. For lift coefficients from 0.6 to 1.8, the maximum shift of neutral point due to power and flap deflection was about 7 percent M.A.C. forward of the location for low lift coefficients with power off and flaps neutral.

INTRODUCTION

General practice in designing the horizontal tail of an airplane has been to design for longitudinal stability in the power-off condition and to allow for the effect of power. Available flight data on the effects of power on longitudinal stability have been analyzed to obtain an indication of the magnitude of these effects on existing designs. The present report shows the effect of power on the stick-fixed neutral point for several single-engine monoplanes with flaps neutral and deflected.

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The results reported herein also indicate the effect of power on the stick-free neutral points, since the stick-free neutral points are usually shifted from the stick-fixed neutral points by a fairly uniform amount that is not greatly affected by power.

DETERMINATION OF STICK-FIXED NEUTRAL POINTS

The procedure for evaluating the stick-fixed neutral points from flight data is illustrated in figure 1 with the data for one of the airplanes included in the present report. The variation of elevator trim angle with lift coefficient as determined in straight and steady flight is first plotted for each of the center-of-gravity locations at which tests were made (fig. 1(a)). The slopes of the curves of figure 1(a) at a given lift coefficient are plotted against the corresponding center-of-gravity location (fig. 1(b)). By extrapolation or interpolation, the neutral point is determined as the center-of-gravity location at which the slope becomes zero and thus indicates neutral stability. The variation of stick-fixed neutral point with lift coefficient obtained by this procedure is shown in figure 1(c).

The accuracy of the method outlined for obtaining neutral points is difficult to state precisely. For the present data, the stick-fixed neutral points are believed to be accurate within approximately $\pm 1\frac{1}{2}$ percent mean aerodynamic chord (M.A.C.). The accuracy of such data may, of course, be improved by making the tests at center-of-gravity locations close to the neutral point and by increasing over the minimum of two the number of center-of-gravity locations investigated. The need for accuracy applies also in the determination of the center-of-gravity locations; in figures 1(a) and 1(b) the center-of-gravity location denoted 28.0 percent M.A.C. appears to be slightly in error.

RESULTS AND DISCUSSION

The results obtained in flight tests of several single-engine monoplanes are shown in figure 2 for flaps neutral and in figure 3 for flaps deflected.

The variation of stick-fixed neutral point with lift coefficient is shown for these airplanes with power off and with rated, climbing, or wave-off power. Sketches of the airplanes to which the data apply are also shown in figure 2 and pertinent dimensions are given in table I.

Flaps neutral.- The results shown in figure 2 indicate that, in general, with power off and flaps neutral, the neutral point either remained fixed or shifted rearward with increasing lift coefficient. Present design procedures, which permit reasonably accurate prediction of the power-off neutral points at low lift coefficients (of the order of $C_L = 0.2$), should therefore be conservative for single-engine monoplanes in the power-off condition with flaps neutral.

The neutral points with rated or climbing power and flaps neutral (fig. 2) were usually forward of the power-off locations by amounts that tended to increase with increasing lift coefficient. The power-on values appeared to fall within fairly well-defined limits with respect to the power-off values at low lift coefficients. Over the entire range of lift coefficient considered (C_L from 0.2 to 1.2), the neutral points with power on generally did not shift more than 4 to 5 percent M.A.C. forward of the power-off location corresponding to low lift coefficients; in only one case did the power-on neutral point shift forward as much as 8 percent M.A.C.

Flaps deflected.- The results of tests with flaps deflected for several of the airplanes are presented in figure 3; data are presented for values of C_L from 0.6 to 1.8. No data were available for airplanes 1, 2, and 3.

As in the case of flaps neutral, the neutral point with flaps deflected and power off remained fixed or shifted rearward with increasing lift coefficient. With power on, the neutral point was usually forward of the power-off location by amounts ranging from 0 to 12 percent M.A.C. and remained constant throughout the range of lift coefficient. With flaps deflected, the maximum forward shift of the power-on neutral point with respect to the location corresponding to low lift coefficients with flaps neutral and power off was about 7 percent M.A.C. This shift will be noted to be less than the shift of 8 percent M.A.C. that was obtained with one of the airplanes with flaps neutral and power on.

CONCLUSIONS

SHIFT IN NEUTRAL POINT DUE TO APPLICATION OF POWER AND FLAP DEFLECTION

A study of available flight data on the effects of power on the stick-fixed neutral points of single-engine monoplanes with flaps neutral and deflected indicated the following conclusions:

1. With power off, the neutral points generally remained fixed or shifted rearward with increasing lift coefficient.

2. With power on, the neutral points were forward of the power-off locations by amounts that tended to increase with increasing lift coefficient. With flaps neutral the most forward location of the neutral point with power on was usually within 4 to 5 percent mean aerodynamic chord (M.A.C.) forward of the power-off location corresponding to low lift coefficients; in only one case was the power-on neutral point shifted forward as much as 8 percent M.A.C. The most forward shift of neutral point due to power and flap deflection was about 7 percent M.A.C. from the location for low lift coefficients with flaps neutral and power off.

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TABLE I

DESCRIPTION OF AIRPLANES TESTED

Airplane	Gross weight as tested (lb)	Wing area (sq ft)	Wing span (ft)	Horizontal tail area (sq ft)	Tail length, 1/4 M.A.C. to elevator hinge line (ft)	Rated engine power (hp)
1	6,400	236	37.3	48.3	18.1	838
2	7,800	248	38.3	45.2	17.1	1050
3	7,500	236	37.0	41.4	17.2	1000
4	7,700	213	34.0	40.0	16.9	1000
5	12,300	422	49.7	107.4	20.9	1500
6	13,000	490	54.2	110.8	24.1	1450
7	5,800	258	39.0	63.6	17.0	850
8	11,300	334	42.8	77.8	20.4	1600

Airplane	Propeller diameter (ft)	Flap type	$\frac{\text{Flap span}}{\text{Wing span}}$ (a)	$\frac{\text{Flap chord}}{\text{Local wing chord}}$	Flap deflection (deg)
1	11.0	----------	---------	---------------	----------
2	11.1	----------	---------	---------------	----------
3	10.5	----------	---------	---------------	----------
4	10.4	Split T.E.	0.55	0.24	43
5	12.0	Split T.E.	.59	.21	60
6	13.0	Split T.E.	.68	.19	45
7	9.0	Split T.E.	.59	.15	67
8	13.1	Slotted	.65	.20	50

[a] Flap span includes section through fuselage not actually covered by flaps.

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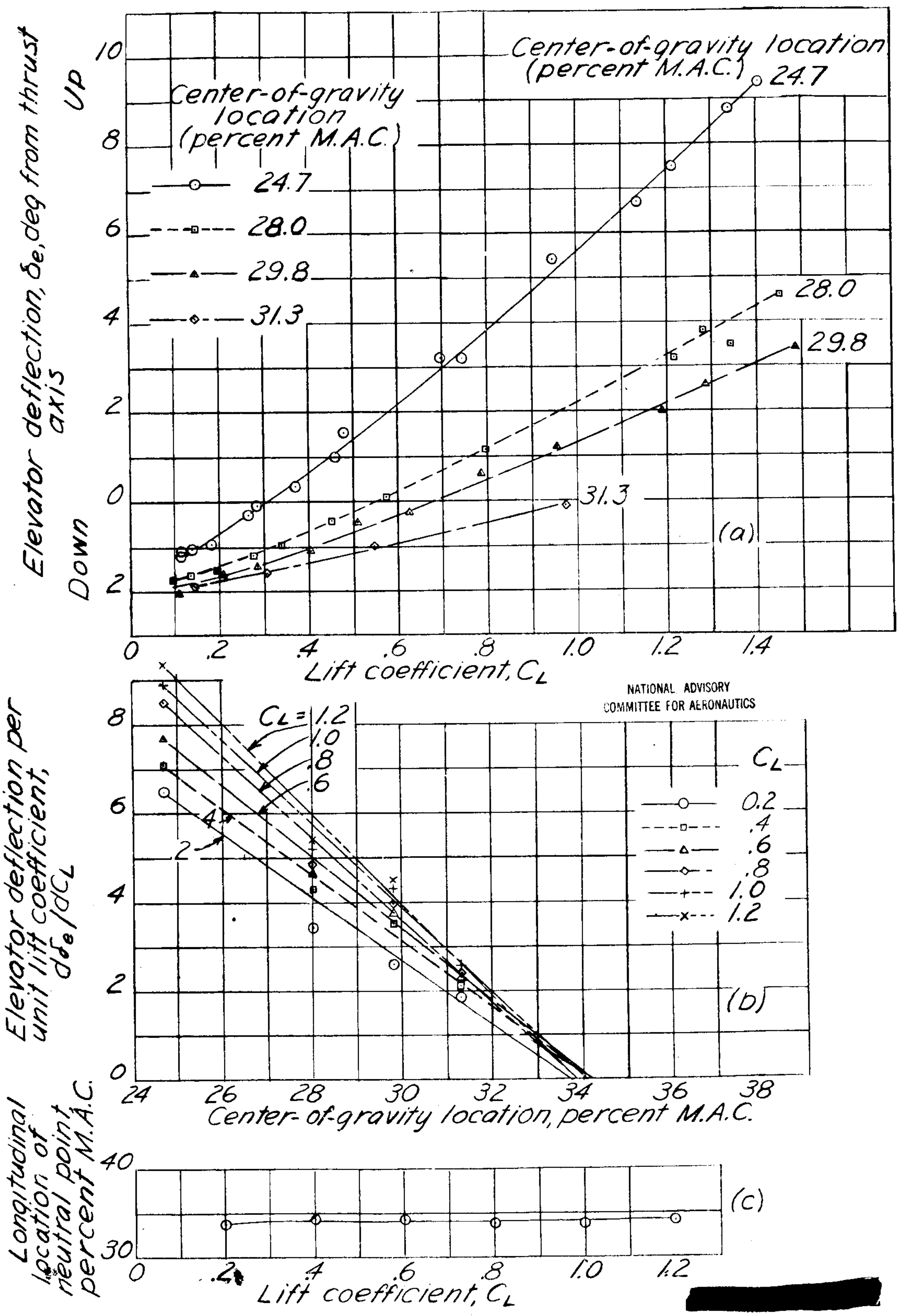

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Figure 1. - Illustration of method for determining stick-fixed neutral points from flight data.

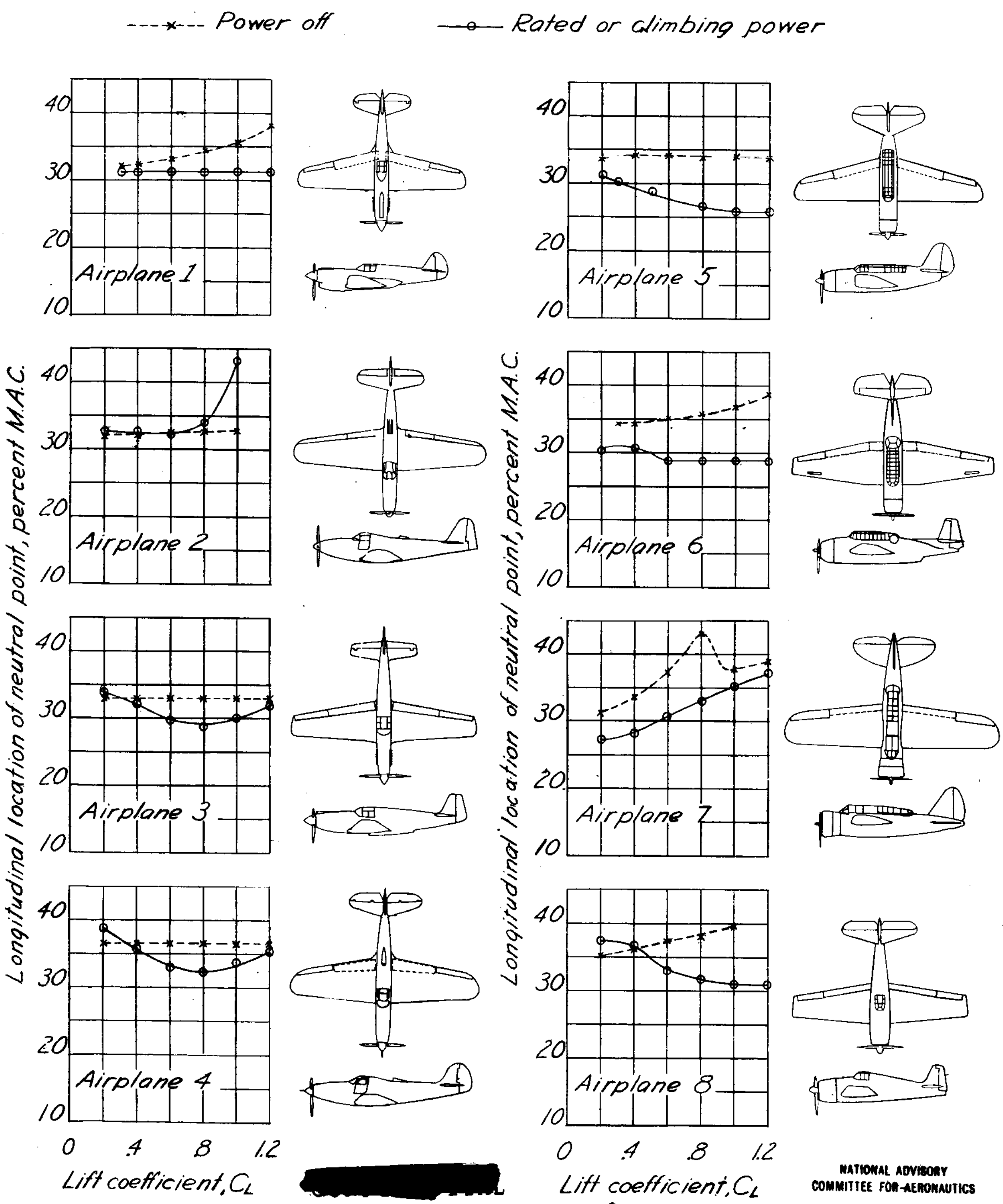

Figure 2.- Variation with lift coefficient of stick-fixed neutral points for several single-engine monoplanes. Flaps neutral.

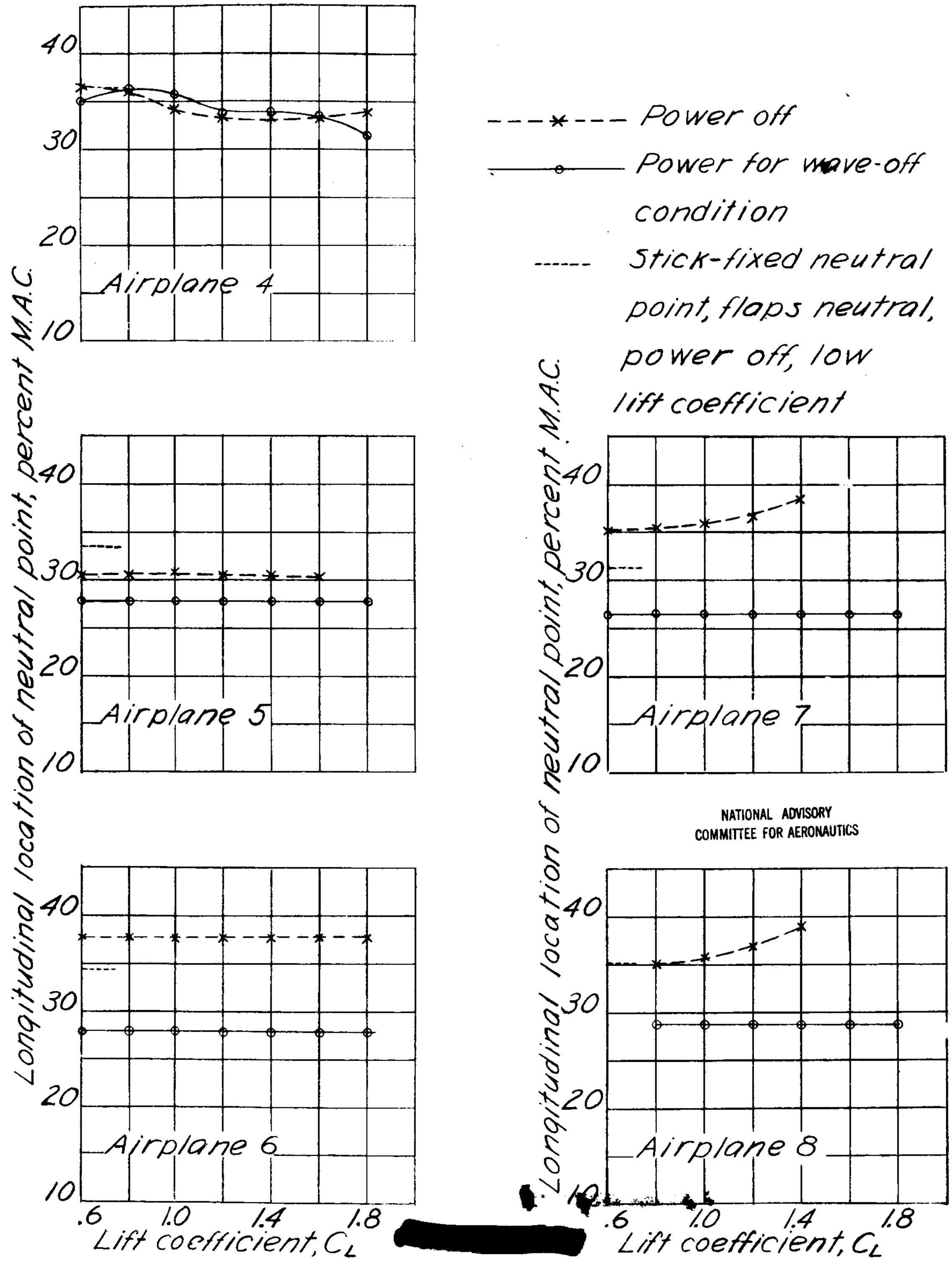

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Figure 3.- Variation with lift coefficient of stick-fixed neutral points for several single-engine monoplanes. Flaps deflected.